Center Innovation Fund: LaRC CIF

Multi-Parameter Measurement in Unseeded Flows using Femtosecond Lasers

Completed Technology Project (2016 - 2017)

Project Introduction

Our approach is to use new turn-key femtosecond laser technology along with new high-speed CMOS camera technology to build a multi-parameter measurement system based on the Princeton-discovered Femtosecond Laser Electronic Excitation and Tagging (FLEET) technique. Our partners at Princeton and others have recently begun using FLEET to study combustion environments and hypersonic flows. We at NASA realized that FLEET was ideally suited for transonic cryogenic facilities like Langley's National Transonic Facility (NTF) and we discovered that the signal intensity scales directly with density near atmospheric conditions, meaning that it works even better under cryo conditions than at room temperature. Another innovative aspect has been to use high-speed camera acquisition technology, allowing velocity, acceleration and pathlines to be measured from each laser excitation pulse. We have recently demonstrated such measurements in attached and separated airfoil flows in the Langley 0.3 meter cryo tunnel which is the pilot facility for NTF. One goal for this year is to analyze and evaluate this airfoil data. Another is to improve our ability to measure temperature with the technique, having demonstrated a rudimentary method this past year. Finally we will investigate how well the technique works in supersonic and hypersonic flows this year. Funding from another program (ARMD AETC) is being used to implement optical access into the NTF for future measurements. SBIR funding is supporting our partner company to investigate alternate versions of FLEET called STARFLEET, which uses less energy thereby perturbing the flow less, and PLEET which uses a picosecond laser which can operate at ~100 kHz (about 100x faster than FLEET). After this year we anticipate bringing the FLEET, STARFLEET and PLEET technologies to NTF to study the freestream and also flowfields around vehicles.

Anticipated Benefits

Currently there is limited or no off-body flow measurement capability in many of Langley's large wind tunnels, including the National Transonic Facility (NTF). Quantitative, multi-parameter flowfield measurements will enable improved understanding of flow physics and provide validation data for computations. Such data may inspire new fluid models (e.g. turbulence models) and would also provide needed boundary conditions for flow computation. The current state of the art technology includes physical probes (pitot, static pressures, thermocouples). Also some laser-based techniques use particles or gases seeded into a flow for velocity measurement. However, probes and seed particles/gases cannot always be used. Sometimes they perturb the flow or impact the facility. Thus there is a significant need for molecular-based measurement techniques for air or N2 flows. Measurements of velocity, density, pressure, temperate and concentration are needed.

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Primary U.S. Work Locations and Key Partners

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

Center Innovation Fund: LaRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

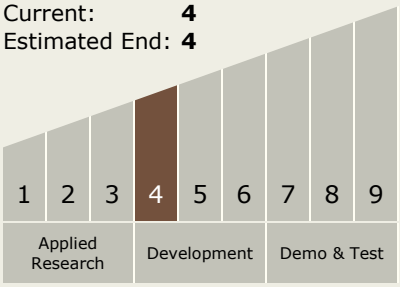
Julie A Williams-byrd

Principal Investigator:

Paul M Danehy

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **4**



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Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia
●Aeronautics Research Mission Directorate(ARMD)	Supporting Organization	NASA Mission Directorate	
George Washington University	Supporting Organization	Academia	Washington, District of Columbia
National Institute of Aerospace	Supporting Organization	Academia	Hampton, Virginia
Princeton University	Supporting Organization	Academia	Princeton, New Jersey
Sandia National Laboratories(SNL)	Supporting Organization	R&D Center	Albuquerque, New Mexico
●Space Technology Mission Directorate(STMD)	Supporting Organization	NASA Mission Directorate	
Spectral Energies, LLC	Supporting Organization	Industry Small Disadvantaged Business (SDB)	Dayton, Ohio

Primary U.S. Work Locations	
District of Columbia	New Jersey
New Mexico	Virginia

Technology Areas

Primary:

- TX15 Flight Vehicle Systems
  - TX15.1 Aerosciences
    - TX15.1.8 Ground and Flight Test Technologies

Target Destination

Earth